2000 CALFED Science Conference
Session Notes

Drinking Water Quality

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Observations Regarding Natural Organic Matter and its effect on drinking water quality in the Sacramento-San Joaquin Delta - Brian Bergamaschi, USGS.

Background:

Dissolved Organic Carbon (DOC):
- *Why do we care?*
- *What is it?*
- *Where does it come from?*
- *Where does it go?*

Why do we care?

DOC is the most interactive with disinfection by-products (DBPs)
- 22 million people drink water from the delta
- increases in DOC and [Br^-] (DBP)
- DBPs potentially exceeds regulations
- Possible 250,000 acres of wetland restoration

Drinking water problems affected by DOC amount and quality:
- DBP formation
- Ozone interaction
- Membrane fouling
- Increased flocculent demand
- Microbial degradation

What is it?

Aromatic structures are big players with DBPs:

- DOC ---(-OCl)---→ HCX_3
  - → Trihalomethane formation
    - STHMFP (discriminator of source of DOC)
      - → UV Absorbance
      - SUVA
      - ^{13}C of THM

% Aromaticity

There should be a good relationship between SUVA and trihalomethane formation potential. We use these relationships to determine the quantity and quality of the DOC.

DOC → (- Ocl, -OBr)
- Trihalomethanes
- Haloacetic Acids
- Haloketones
- Haloacetonitriles
- Halophenols

Where does DOC come from?

A variety of areas:
- Agriculture
- Marsh
- Benthic
- Channels
- Riparian Vegetation

One question to investigate is whether the founding statement is accurate:
Island drainage contributes 40-45% of the carbon that reacts… -DWR Report

Sources	Sinks
River	Microbial degradation
Upland Runoff	Photo-degradation
Algae	Flocculation
Wetlands	

Findings:
1. DOC concentration has an annual cycle ranging from 3-10 mg/L. The large-scale changes in DOC concentration are large-scale, basin wide processes – not related to inputs from a single source or class of sources.
2. There is little evidence that addition of island drainage to Delta channel waters is the *major* cause of the persistent increase of DOC in the Delta
3. The quality is highly variable—as, or more variable than DOC formation. The quality of the DOC is as important as the amount of the DOC in the Delta waters.
4. SUVA does not correspond to THM formation.
5. Delta channels have a high reactivity.
6. Source of THMs in export waters is different than island drains, river water, or channel water.
7. Channel water DOC is NOT a simple mixture of peat-island-derived carbon and river-borne carbon.

8. Processes within the Delta channel waters are affecting the quality and amount of DOC.

Effects of Constructed Wetlands for Subsidence Mitigation on Drinking Water Quality, Sacramento-San Joaquin Delta - Roger Fujii, USGS.

There have been significant amounts of subsidence in the Delta (up to 25 ft). For over 10 yrs the USGS has conducted subsidence mitigation research with a focus on the use of wetlands for a possible solution. It is a long-term priority for maintaining levee integrity and restoring tidal wetland habitat.

What are the effects of wetlands on water quality?
- Concentration and quality of DOC (DBP precursors)
- Changes in DOC concentration and quality with maturity
- Comparisons with agricultural sites

Effects of conversion of agricultural fields to constructed wetlands:
- Aerobic to anaerobic soils (redox)
- Changes in microbial communities
- Different NOM decomposition rates and pathways
- Growth of wetland vegetation
- And more…

The project:
- Constructed wetland habitat test ponds
  - Open water
  - Reverse flooding
  - Permanently flooded
- With a comparison of an agricultural operation
  - Corn field on Twitchell Island
  - peat soils and traditional Delta water management practices
  - near-surface soil water taken with lysimeter

…measured the near surface soil water and surface water at the pond, the inflow, and the outflow for DOC, THMFP, SUVA and STHMFP.

DOC quality parameters:

- SUVA measures UV absorbance at 254nm/DOC and is an indicator of DOC aromaticity
- STHMFP is the THMFP/DOC and indicates the reactivity of DOC to form THMs.

Wetland Summary:

(listed in order of lowest median concentration to highest median concentration sites)

DOC, soil water
- Open water pond
- Flooded pond
- Ag soil
- Reverse flooded pond
- Flooded wetland

DOC, surface water
- Sacramento River
- San Joaquin River
- Flooded pond
- Flooded wetland, SW
- Flooded wetland outlet
- Open water pond

THMFP, soil water
- Open water
- Flooded pond
- Ag soil
- Flooded wetland
- Reverse flooded pond

THMFP, surface water
- Sacramento River
- San Joaquin River
- Flooded pond
- Flooded wetland, SW
- Flooded wetland, outlet
- Open water pond

SUVA, soil water
- Ag soil
- Flooded wetland
- Reverse flooded pond
- Flooded pond
- Open water

SUVA, surface water
- Sacramento River
- San Joaquin River
- Flooded pond
- Flooded wetland, SW
- Flooded wetland, outlet
- Open water pond

STHMFP, soil water
- Flooded wetland
- Ag soil
- Flooded pond
- Reverse flooded pond
- Open water pond

STHMFP, soil water
- San Joaquin River
- Sacramento River
- Flooded wetland, outlet
- Flooded pond
- Open water pond
- Flooded wetland, SW

Need to assess
- Concentrations and loads
- DOC, THM precursors and carbon quality:
  - STHMFP, optical properties, isotopes…
- NOM sources
- Processes: NOM dynamics, hydrology

A mechanistic understanding of these processes will help build quantitative MODELS and provide the tools necessary to estimate impacts of conversion of agriculture to wetlands on drinking water quality.

Tools for Identifying Sources of Problematic Natural Organic Matter in Sacramento San Joaquin Delta Waters: A success story from Sweetwater Reservoir - Miranda S. Fram, USGS.

Using the Sweetwater success story to demonstrate that studies of sources of dissolved organic carbon (DOC) and trihalomethane (THM) precursors can yield practical applications for improving drinking water quality.
Sweetwater: local suppliers of water in San Diego
- Water has high DOC and [Br^-]
- High levels of THM and other disinfection byproducts (DBPs)
- Some of the same potential sources as the Delta
- Very small scale and simple compared to the Delta

Potential sources of organic carbon: common to Sweetwater and Delta
Riverine input
- Sweetwater River – annual transfer from upstream reservoir
- Sacramento and San Joaquin Rivers - flow all year

Wetlands
- Riparian wetland species habitat at east end of reservoir
- Riparian, tidal and non-tidal wetlands of many types

Algal and microbial productivity
- Primary productivity in Sweetwater reservoir
- Primary productivity in Delta channels

Sweetwater annual refilling experiment
- Monitor DOC and SC in upstream reservoir, along river, and in Sweetwater reservoir before, during, and after release of water
- Construct mass balance
  - SC (analog for [Br^-]): excess contributed from washout of river channel
  - DOC: excess contributed from washout AND from newly flooded zone of reservoir.
- Newly inundated area – decomposing mowed vegetation
  - High DOC concentrations
  - DOC very reactive with respect to THM formation (high STHMFP)

DOC parameters:
- Quantity – concentrations and loads
- Quality – chemical composition of DOC (e.g., specific THM formation potential (STHMFP) and kinetics of reaction with chlorine).

Sweetwater DOC and THM precursor sources
Sweetwater River
- Contributes excess DOC and [Br^-]
- Mitigation strategy: divert leading edge of transfer

Wetlands

Locally high DOC concentrations with high STHMFP
Minor contributor to DOC load in reservoir

Inundated zone

High DOC and high STHMFP concentrations and loads from decomposing,
mowed vegetation.
Mitigation strategy: harvest vegetation

Algae

Contribute DOC to water and are THM precursors

Sweetwater success story

- Determined most important sources of DOC and THM precursors to reservoir
- Suggest three relatively simple changes in reservoir management strategies that could result in a 10-40% reduction in THM formation during water treatment.

Application to Delta: Use the same scientific approach – systematic investigation of sources and composition of DOC, POC, and THM precursors.